

CHARMED, STRANGE MESONS ($C = S = \pm 1$)

$D_s^+ = c\bar{s}$, $D_s^- = \bar{c}s$, similarly for D_s^{*+} 's

D_s^\pm

$I(J^P) = 0(0^-)$

Mass $m = 1968.34 \pm 0.07$ MeV

$m_{D_s^\pm} - m_{D^\pm} = 98.69 \pm 0.05$ MeV

Mean life $\tau = (504 \pm 4) \times 10^{-15}$ s ($S = 1.2$)

$c\tau = 151.2 \mu\text{m}$

CP -violating decay-rate asymmetries

$$A_{CP}(\mu^\pm\nu) = (5 \pm 6)\%$$

$$A_{CP}(K^\pm K_S^0) = (0.08 \pm 0.26)\%$$

$$A_{CP}(K^+ K^- \pi^\pm) = (-0.5 \pm 0.9)\%$$

$$A_{CP}(\phi\pi^\pm) = (-0.38 \pm 0.27)\%$$

$$A_{CP}(K^\pm K_S^0 \pi^0) = (-2 \pm 6)\%$$

$$A_{CP}(2K_S^0 \pi^\pm) = (3 \pm 5)\%$$

$$A_{CP}(K^+ K^- \pi^\pm \pi^0) = (0.0 \pm 3.0)\%$$

$$A_{CP}(K^\pm K_S^0 \pi^+ \pi^-) = (-6 \pm 5)\%$$

$$A_{CP}(K_S^0 K^\mp 2\pi^\pm) = (4.1 \pm 2.8)\%$$

$$A_{CP}(\pi^+ \pi^- \pi^\pm) = (-0.7 \pm 3.1)\%$$

$$A_{CP}(\pi^\pm \eta) = (1.1 \pm 3.1)\%$$

$$A_{CP}(\pi^\pm \eta') = (-0.9 \pm 0.5)\%$$

$$A_{CP}(\eta \pi^\pm \pi^0) = (-1 \pm 4)\%$$

$$A_{CP}(\eta' \pi^\pm \pi^0) = (0 \pm 8)\%$$

$$A_{CP}(K^\pm \pi^0) = (-27 \pm 24)\%$$

$$A_{CP}(\overline{K}^0 / K^0 \pi^\pm) = (0.4 \pm 0.5)\%$$

$$A_{CP}(K_S^0 \pi^\pm) = (3.1 \pm 2.6)\% \quad (S = 1.7)$$

$$A_{CP}(K^\pm \pi^+ \pi^-) = (4 \pm 5)\%$$

$$A_{CP}(K^\pm \eta) = (9 \pm 15)\%$$

$$A_{CP}(K^\pm \eta'(958)) = (6 \pm 19)\%$$

CP violating asymmetries of P -odd (T -odd) moments

$$A_T(K_S^0 K^\pm \pi^+ \pi^-) = (-14 \pm 8) \times 10^{-3} \quad [a]$$

$D_s^+ \rightarrow \phi \ell^+ \nu_\ell$ form factors

$$r_2 = 0.84 \pm 0.11 \quad (S = 2.4)$$

$$r_v = 1.80 \pm 0.08$$

$$\Gamma_L/\Gamma_T = 0.72 \pm 0.18$$

Unless otherwise noted, the branching fractions for modes with a resonance in the final state include all the decay modes of the resonance. D_s^- modes are charge conjugates of the modes below.

D_s^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Inclusive modes			
e^+ semileptonic	[b] $(6.5 \pm 0.4)\%$	—	—
π^+ anything	$(119.3 \pm 1.4)\%$	—	—
π^- anything	$(43.2 \pm 0.9)\%$	—	—
π^0 anything	$(123 \pm 7)\%$	—	—
K^- anything	$(18.7 \pm 0.5)\%$	—	—
K^+ anything	$(28.9 \pm 0.7)\%$	—	—
K_S^0 anything	$(19.0 \pm 1.1)\%$	—	—
η anything	[c] $(29.9 \pm 2.8)\%$	—	—
ω anything	$(6.1 \pm 1.4)\%$	—	—
η' anything	[d] $(10.3 \pm 1.4)\%$	S=1.1	—
$f_0(980)$ anything, $f_0 \rightarrow \pi^+ \pi^-$	< 1.3 %	CL=90%	—
ϕ anything	$(15.7 \pm 1.0)\%$	—	—
$K^+ K^-$ anything	$(15.8 \pm 0.7)\%$	—	—
$K_S^0 K^+$ anything	$(5.8 \pm 0.5)\%$	—	—
$K_S^0 K^-$ anything	$(1.9 \pm 0.4)\%$	—	—
$2K_S^0$ anything	$(1.70 \pm 0.32)\%$	—	—
$2K^+$ anything	< 2.6×10^{-3}	CL=90%	—
$2K^-$ anything	< 6×10^{-4}	CL=90%	—
Leptonic and semileptonic modes			
$e^+ \nu_e$	< 8.3×10^{-5}	CL=90%	984
$\mu^+ \nu_\mu$	$(5.50 \pm 0.23) \times 10^{-3}$	—	981
$\tau^+ \nu_\tau$	$(5.48 \pm 0.23)\%$	—	182
$K^+ K^- e^+ \nu_e$	—	—	851
$\phi e^+ \nu_e$	[e] $(2.39 \pm 0.16)\%$	S=1.3	720
$\phi \mu^+ \nu_\mu$	$(1.9 \pm 0.5)\%$	—	715
$\eta e^+ \nu_e + \eta'(958) e^+ \nu_e$	[e] $(3.03 \pm 0.24)\%$	—	—
$\eta e^+ \nu_e$	[e] $(2.29 \pm 0.19)\%$	—	908
$\eta'(958) e^+ \nu_e$	[e] $(7.4 \pm 1.4) \times 10^{-3}$	—	751
$\eta \mu^+ \nu_\mu$	$(2.4 \pm 0.5)\%$	—	905
$\eta'(958) \mu^+ \nu_\mu$	$(1.1 \pm 0.5)\%$	—	747
$\omega e^+ \nu_e$	[f] < 2.0×10^{-3}	CL=90%	829
$K^0 e^+ \nu_e$	$(3.9 \pm 0.9) \times 10^{-3}$	—	921
$K^*(892)^0 e^+ \nu_e$	[e] $(1.8 \pm 0.4) \times 10^{-3}$	—	782

Hadronic modes with a $K\bar{K}$ pair

$K^+ K_S^0$	(-1.50 ± 0.05) %	850
$K^+ \bar{K}^0$	(2.95 ± 0.14) %	850
$K^+ K^- \pi^+$	[g] (5.45 ± 0.17) %	S=1.2 805
$\phi \pi^+$	[e,h] (4.5 ± 0.4) %	712
$\phi \pi^+, \phi \rightarrow K^+ K^-$	[h] (2.27 ± 0.08) %	712
$K^+ \bar{K}^*(892)^0, \bar{K}^{*0} \rightarrow$	(2.61 ± 0.09) %	416
$K^- \pi^+$		
$f_0(980)\pi^+, f_0 \rightarrow K^+ K^-$	(1.15 ± 0.32) %	732
$f_0(1370)\pi^+, f_0 \rightarrow K^+ K^-$	(7 ± 5) $\times 10^{-4}$	—
$f_0(1710)\pi^+, f_0 \rightarrow K^+ K^-$	(6.7 ± 2.9) $\times 10^{-4}$	198
$K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^* \rightarrow$	(1.9 ± 0.4) $\times 10^{-3}$	218
$K^- \pi^+$		
$K^+ K_S^0 \pi^0$	(1.52 ± 0.22) %	805
$2K_S^0 \pi^+$	(7.7 ± 0.6) $\times 10^{-3}$	802
$K^0 \bar{K}^0 \pi^+$	—	802
$K^*(892)^+ \bar{K}^0$	[e] (5.4 ± 1.2) %	683
$K^+ K^- \pi^+ \pi^0$	(6.3 ± 0.6) %	748
$\phi \rho^+$	[e] ($8.4^{+1.9}_{-2.3}$) %	401
$K_S^0 K^- 2\pi^+$	(1.68 ± 0.10) %	744
$K^*(892)^+ \bar{K}^*(892)^0$	[e] (7.2 ± 2.6) %	417
$K^+ K_S^0 \pi^+ \pi^-$	(1.00 ± 0.08) %	744
$K^+ K^- 2\pi^+ \pi^-$	(8.7 ± 1.5) $\times 10^{-3}$	673
$\phi 2\pi^+ \pi^-$	[e] (1.21 ± 0.16) %	640
$K^+ K^- \rho^0 \pi^+ \text{non-}\phi$	< 2.6×10^{-4} CL=90%	249
$\phi \rho^0 \pi^+, \phi \rightarrow K^+ K^-$	(6.5 ± 1.3) $\times 10^{-3}$	181
$\phi a_1(1260)^+, \phi \rightarrow$	(7.5 ± 1.2) $\times 10^{-3}$	†
$K^+ K^-, a_1^+ \rightarrow \rho^0 \pi^+$		
$K^+ K^- 2\pi^+ \pi^- \text{nonresonant}$	(9 ± 7) $\times 10^{-4}$	673
$2K_S^0 2\pi^+ \pi^-$	(9 ± 4) $\times 10^{-4}$	669

Hadronic modes without K 's

$\pi^+ \pi^0$	< 3.5×10^{-4} CL=90%	975
$2\pi^+ \pi^-$	(1.09 ± 0.05) % S=1.1 959	959
$\rho^0 \pi^+$	(2.0 ± 1.2) $\times 10^{-4}$	825
$\pi^+ (\pi^+ \pi^-)_{S-\text{wave}}$	[i] (9.1 ± 0.4) $\times 10^{-3}$	959
$f_2(1270)\pi^+, f_2 \rightarrow \pi^+ \pi^-$	(1.10 ± 0.20) $\times 10^{-3}$	559
$\rho(1450)^0 \pi^+, \rho^0 \rightarrow \pi^+ \pi^-$	(3.0 ± 2.0) $\times 10^{-4}$	421
$\pi^+ 2\pi^0$	(6.5 ± 1.3) $\times 10^{-3}$	961
$2\pi^+ \pi^- \pi^0$	—	935
$\eta \pi^+$	[e] (1.70 ± 0.09) % S=1.1 902	902
$\omega \pi^+$	[e] (2.4 ± 0.6) $\times 10^{-3}$	822
$3\pi^+ 2\pi^-$	(8.0 ± 0.8) $\times 10^{-3}$	899

$2\pi^+\pi^-2\pi^0$	—	902
$\eta\rho^+$	[e] (8.9 ± 0.8) %	724
$\eta\pi^+\pi^0$	(9.2 ± 1.2) %	885
$\omega\pi^+\pi^0$	[e] (2.8 ± 0.7) %	802
$3\pi^+2\pi^-\pi^0$	(4.9 ± 3.2) %	856
$\omega 2\pi^+\pi^-$	[e] (1.6 ± 0.5) %	766
$\eta'(958)\pi^+$	[d,e] (3.94 ± 0.25) %	743
$3\pi^+2\pi^-2\pi^0$	—	803
$\omega\eta\pi^+$	[e] < 2.13 % CL=90%	654
$\eta'(958)\rho^+$	[d,e] (5.8 ± 1.5) %	465
$\eta'(958)\pi^+\pi^0$	(5.6 ± 0.8) %	720
$\eta'(958)\pi^+\pi^0$ nonresonant	< 5.1 % CL=90%	720

Modes with one or three K 's

$K^+\pi^0$	(6.3 ± 2.1) $\times 10^{-4}$	917
$K_S^0\pi^+$	(1.22 ± 0.06) $\times 10^{-3}$	916
$K^+\eta$	[e] (1.77 ± 0.35) $\times 10^{-3}$	835
$K^+\omega$	[e] < 2.4 $\times 10^{-3}$ CL=90%	741
$K^+\eta'(958)$	[e] (1.8 ± 0.6) $\times 10^{-3}$	646
$K^+\pi^+\pi^-$	(6.6 ± 0.4) $\times 10^{-3}$	900
$K^+\rho^0$	(2.5 ± 0.4) $\times 10^{-3}$	745
$K^+\rho(1450)^0, \rho^0 \rightarrow \pi^+\pi^-$	(7.0 ± 2.4) $\times 10^{-4}$	—
$K^*(892)^0\pi^+, K^{*0} \rightarrow$	(1.42 ± 0.24) $\times 10^{-3}$	775
$K^+\pi^-$		—
$K^*(1410)^0\pi^+, K^{*0} \rightarrow$	(1.24 ± 0.29) $\times 10^{-3}$	—
$K^+\pi^-$		—
$K^*(1430)^0\pi^+, K^{*0} \rightarrow$	(5.0 ± 3.5) $\times 10^{-4}$	—
$K^+\pi^-$		—
$K^+\pi^+\pi^-$ nonresonant	(1.04 ± 0.34) $\times 10^{-3}$	900
$K^0\pi^+\pi^0$	(1.00 ± 0.18) %	899
$K_S^02\pi^+\pi^-$	(3.0 ± 1.1) $\times 10^{-3}$	870
$K^+\omega\pi^0$	[e] < 8.2 $\times 10^{-3}$ CL=90%	684
$K^+\omega\pi^+\pi^-$	[e] < 5.4 $\times 10^{-3}$ CL=90%	603
$K^+\omega\eta$	[e] < 7.9 $\times 10^{-3}$ CL=90%	366
$2K^+K^-$	(2.18 ± 0.21) $\times 10^{-4}$	628
$\phi K^+, \phi \rightarrow K^+K^-$	(8.9 ± 2.0) $\times 10^{-5}$	—

Doubly Cabibbo-suppressed modes

$2K^+\pi^-$	(1.27 ± 0.13) $\times 10^{-4}$	805
$K^+K^*(892)^0, K^{*0} \rightarrow$	(6.0 ± 3.4) $\times 10^{-5}$	—
$K^+\pi^-$		—

Baryon-antibaryon mode

$p\bar{n}$	(1.22 ± 0.11) $\times 10^{-3}$	295
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**$\Delta C = 1$ weak neutral current (*C1*) modes,
Lepton family number (*LF*), or
Lepton number (*L*) violating modes**

$\pi^+ e^+ e^-$	[j] < 1.3	$\times 10^{-5}$	CL=90%	979
$\pi^+ \phi, \phi \rightarrow e^+ e^-$	[k] (6 +8 -4) $\times 10^{-6}$		-	
$\pi^+ \mu^+ \mu^-$	[j] < 4.1	$\times 10^{-7}$	CL=90%	968
$K^+ e^+ e^-$	<i>C1</i> < 3.7	$\times 10^{-6}$	CL=90%	922
$K^+ \mu^+ \mu^-$	<i>C1</i> < 2.1	$\times 10^{-5}$	CL=90%	909
$K^*(892)^+ \mu^+ \mu^-$	<i>C1</i> < 1.4	$\times 10^{-3}$	CL=90%	765
$\pi^+ e^+ \mu^-$	<i>LF</i> < 1.2	$\times 10^{-5}$	CL=90%	976
$\pi^+ e^- \mu^+$	<i>LF</i> < 2.0	$\times 10^{-5}$	CL=90%	976
$K^+ e^+ \mu^-$	<i>LF</i> < 1.4	$\times 10^{-5}$	CL=90%	919
$K^+ e^- \mu^+$	<i>LF</i> < 9.7	$\times 10^{-6}$	CL=90%	919
$\pi^- 2e^+$	<i>L</i> < 4.1	$\times 10^{-6}$	CL=90%	979
$\pi^- 2\mu^+$	<i>L</i> < 1.2	$\times 10^{-7}$	CL=90%	968
$\pi^- e^+ \mu^+$	<i>L</i> < 8.4	$\times 10^{-6}$	CL=90%	976
$K^- 2e^+$	<i>L</i> < 5.2	$\times 10^{-6}$	CL=90%	922
$K^- 2\mu^+$	<i>L</i> < 1.3	$\times 10^{-5}$	CL=90%	909
$K^- e^+ \mu^+$	<i>L</i> < 6.1	$\times 10^{-6}$	CL=90%	919
$K^*(892)^- 2\mu^+$	<i>L</i> < 1.4	$\times 10^{-3}$	CL=90%	765

 $D_s^{*\pm}$ $I(J^P) = 0(?^?)$ J^P is natural, width and decay modes consistent with 1^- .Mass $m = 2112.2 \pm 0.4$ MeV $m_{D_s^{*\pm}} - m_{D_s^\pm} = 143.8 \pm 0.4$ MeVFull width $\Gamma < 1.9$ MeV, CL = 90% D_s^{*-} modes are charge conjugates of the modes below.

D_s^{*+} DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D_s^+ \gamma$	(93.5±0.7) %	139
$D_s^+ \pi^0$	(5.8±0.7) %	48
$D_s^+ e^+ e^-$	(6.7±1.6) $\times 10^{-3}$	139

$D_{s0}^*(2317)^{\pm}$

$I(J^P) = 0(0^+)$
 J, P need confirmation.

J^P is natural, low mass consistent with 0^+ .

Mass $m = 2317.8 \pm 0.5$ MeV

$$m_{D_{s0}^*(2317)^{\pm}} - m_{D_s^{\pm}} = 349.4 \pm 0.5 \text{ MeV}$$

Full width $\Gamma < 3.8$ MeV, CL = 95%

$D_{s0}^*(2317)^-$ modes are charge conjugates of modes below.

$D_{s0}^*(2317)^{\pm}$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$D_s^+ \pi^0$	$(100 \pm 0) \%$		298
$D_s^+ \gamma$	$< 5 \%$	90%	323
$D_s^*(2112)^+ \gamma$	$< 6 \%$	90%	—
$D_s^+ \gamma \gamma$	$< 18 \%$	95%	323
$D_s^*(2112)^+ \pi^0$	$< 11 \%$	90%	—
$D_s^+ \pi^+ \pi^-$	$< 4 \times 10^{-3}$	90%	194
$D_s^+ \pi^0 \pi^0$	not seen		205

$D_{s1}(2460)^{\pm}$

$I(J^P) = 0(1^+)$

Mass $m = 2459.5 \pm 0.6$ MeV (S = 1.1)

$$m_{D_{s1}(2460)^{\pm}} - m_{D_s^{*\pm}} = 347.3 \pm 0.7 \text{ MeV} \quad (\text{S} = 1.2)$$

$$m_{D_{s1}(2460)^{\pm}} - m_{D_s^{\pm}} = 491.2 \pm 0.6 \text{ MeV} \quad (\text{S} = 1.1)$$

Full width $\Gamma < 3.5$ MeV, CL = 95%

$D_{s1}(2460)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2460)^+$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$D_s^{*+} \pi^0$	$(48 \pm 11) \%$		297
$D_s^+ \gamma$	$(18 \pm 4) \%$		442
$D_s^+ \pi^+ \pi^-$	$(4.3 \pm 1.3) \%$	S=1.1	363
$D_s^{*+} \gamma$	$< 8 \%$	CL=90%	323
$D_{s0}^*(2317)^+ \gamma$	$(3.7 \pm 5.0) \%$		138

$D_{s1}(2536)^{\pm}$

$I(J^P) = 0(1^+)$
 J, P need confirmation.

Mass $m = 2535.11 \pm 0.06$ MeV

Full width $\Gamma = 0.92 \pm 0.05$ MeV

$D_{s1}(2536)^-$ modes are charge conjugates of the modes below.

$D_{s1}(2536)^+$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$D^*(2010)^+ K^0$	0.85 ± 0.12		149
$(D^*(2010)^+ K^0)_{S-wave}$	0.61 ± 0.09		149
$D^+ \pi^- K^+$	0.028 ± 0.005		176
$D^*(2007)^0 K^+$	DEFINED AS 1		167
$D^+ K^0$	<0.34	90%	381
$D^0 K^+$	<0.12	90%	391
$D_s^{*+} \gamma$	possibly seen		388
$D_s^+ \pi^+ \pi^-$	seen		437

$D_{s2}^*(2573)$

$I(J^P) = 0(2^+)$

J^P is natural, width and decay modes consistent with 2^+ .

Mass $m = 2569.1 \pm 0.8$ MeV (S = 2.4)

Full width $\Gamma = 16.9 \pm 0.7$ MeV

$D_{s2}^*(2573)^-$ modes are charge conjugates of the modes below.

$D_{s2}^*(2573)^+$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$D^0 K^+$	seen	431
$D^*(2007)^0 K^+$	not seen	238

$D_{s1}^*(2700)^{\pm}$

$I(J^P) = 0(1^-)$

Mass $m = 2708.3^{+4.0}_{-3.4}$ MeV

Full width $\Gamma = 120 \pm 11$ MeV

NOTES

- [a] See the Particle Listings for the (complicated) definition of this quantity.
- [b] This is the purely e^+ semileptonic branching fraction: the e^+ fraction from τ^+ decays has been subtracted off. The sum of our (non- τ) e^+ exclusive fractions — an $e^+ \nu_e$ with an η , η' , ϕ , K^0 , or K^{*0} — is $5.99 \pm 0.31\%$.
- [c] This fraction includes η from η' decays.
- [d] The sum of our exclusive η' fractions — $\eta' e^+ \nu_e$, $\eta' \mu^+ \nu_\mu$, $\eta' \pi^+$, $\eta' \rho^+$, and $\eta' K^+$ — is $11.8 \pm 1.6\%$.
- [e] This branching fraction includes all the decay modes of the final-state resonance.
- [f] A test for $u\bar{u}$ or $d\bar{d}$ content in the D_s^+ . Neither Cabibbo-favored nor Cabibbo-suppressed decays can contribute, and $\omega-\phi$ mixing is an unlikely explanation for any fraction above about 2×10^{-4} .
- [g] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.
- [h] We decouple the $D_s^+ \rightarrow \phi \pi^+$ branching fraction obtained from mass projections (and used to get some of the other branching fractions) from the $D_s^+ \rightarrow \phi \pi^+$, $\phi \rightarrow K^+ K^-$ branching fraction obtained from the Dalitz-plot analysis of $D_s^+ \rightarrow K^+ K^- \pi^+$. That is, the ratio of these two branching fractions is not exactly the $\phi \rightarrow K^+ K^-$ branching fraction 0.491.
- [i] This is the average of a model-independent and a K -matrix parametrization of the $\pi^+ \pi^-$ S -wave and is a sum over several f_0 mesons.
- [j] This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.
- [k] This is *not* a test for the $\Delta C=1$ weak neutral current, but leads to the $\pi^+ \ell^+ \ell^-$ final state.